GENERIC CALCULATION OF RE-USE DISTANCES ASSUMING 50' MAXIMUM RANGE

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|-----------|-----------|-----------|
| General | Center Frequency | Fc | 5.85 | GHz |
| . | Speed of Light | Cf | 984251969 | feet/sec. |
| | Wavelength | Lambda | 0.1682482 | feet |
| | Wavelength in dB | Lambda_dB | -7.74 | dB feet |
| | 4*PI | F_PI | 10.99 | dB |
| | Maximum Operating Range | Rmax | 50.00 | |
| | Maximum Operating Range in dB | Rmax_dB | 16.99 | |
| RSU | Antenna Gain | RSU_g | 20.00 | dB |
| | Antenna Radiation Pattern Loss | RSU_gl | 3.00 | dB |
| | Minimum Loss Through Antenna Sidelobes | RSU_sl | 15.00 | dB |
| [| Maximum Antenna Gain Through Sidelobes | RSU_gsl | 5.00 | dB |
| | Minimum Received Signal Level (rcvr.) | RSU_mrsl | -94.00 | |
| J | Maximum Interference Signal Level (rcvr.) | RSU_int | -114.00 | dBm |
| 1 | Maximum Transmit EIRP | RSU_Pmax | | dBm |
| 1 | Isolation Tone to Lower Uplink Band | RSU_TL | 60.00 | B |
| 1 | Isolation Tone to Upper Uplink Band | RSU_TU | 60.00 | dB |
| | Isolation Tone to Adjacent Channel | RSU_TA | 80.00 | dB |
| | Class A: Isolation Modulated to Lower Uplink | RSU_AML | 40.00 | dB |
| | Class A: Isolation Modulated to Upper Uplink | RSU_AMU | 60.00 | dB |
| | Class A: Isolation Modulated to Adjacent Channel | RSU_AMA | 63.00 | dB |
| | Class B: Isolation Modulated to Lower Uplink | RSU_BML | 50.00 | dB |
| 1 | Class B: Isolation Modulated to Upper Uplink | RSU_BMU | 60.00 | dB |
| İ | Class B: Isolation Modulated to Adjacent Channel | RSU_BMA | 70.00 | dB |
|] | Class C: Isolation Modulated to Lower Uplink | RSU_CML | 60.00 | dB |
| | Class C: Isolation Modulated to Upper Uplink | RSU_CMU | 60.00 | dB |
| | Class C: Isolation Modulated to Adjacent Channel | RSU_CMA | 80.00 | dB |
| OBU | Antenna Gain (35 degrees off boresight) | OBU_g | 4.00 | dB |
| | Mimimum Received Signal Level (0 dB ant) | OBU_min | -40.00 | dBm |
| | Maximum Received Signal Level (0 dB ant) | OBU_max | -14.00 | dBm |
| | Maximum Transmit EIRP | OBU Pmax | -24.00 | dBm |
| | Maximum Interference Signal Level (0 dB ant) | OBU int | -60.00 | |
| | Windscreen Loss, One-Way | L_w | 3.00 | |
| 1 | Modulation Loss | L_m | 3.00 | |
| 1 | Realization Margin | Lr | 4.00 | |
| | RF Amplifier Gain | OBU_rf | 10.00 | |
| | Minimum Conversion Gain | OBU_Gain | | |
| | Adjacent Channel Isolation | OBU_AI | 18.00 | |

GENERIC CALCULATION OF RE-USE DISTANCES ASSUMING 50' MAXIMUM RANGE EIRP (CONTINUED)

Uplink on Uplink Separation Distance OBU to RSU

| RSU Antenna | Antennas | SCENARIO | LABEL | VALUE | UNITS |
|-------------|-----------------|----------|-------|----------|-------|
| Mainlobe | Same Channel | | | 4,233.90 | feet |
| | Adjacent Channe | el | | 533.02 | feet |
| Sidelobe | Same Channel | | | 752.91 | feet |
| | Adjacent Channe | el . | | 94.79 | feet |

Downlink on Uplink Separation Distance RSU to RSU

| RSU Antenna | Downlink on Uplink Separation Distance R Antennas SCENARIO | LABEL | VALUE | UNITS |
|-------------|--|-------|----------|-------|
| Mainlobe | Tone to Lower Uplink Band | | 671.03 | feet |
| | Tone to Upper Uplink Band | | 671.03 | feet |
| | Tone to Adjacent Channel | | 67.10 | feet |
| | Class A: Modulated to Lower Uplink Band | | 6,710.28 | feet |
| | Class A: Modulated to Upper Uplink Band | | 671.03 | feet |
| | Class A: Modulated to Adjacent Channel | | 475.05 | feet |
| | Class B: Modulated to Lower Uplink Band | | 2,121.98 | feet |
| | Class B: Modulated to Upper Uplink Band | | 671.03 | feet |
| 1 | Class B: Modulated to Adjacent Channel | | 212.20 | feet |
| | Class C: Modulated to Lower Uplink Band | | 671.03 | feet |
| | Class C: Modulated to Upper Uplink Band | | 671.03 | feet |
| | Class C: Modulated to Adjacent Channel | | 67.10 | feet |
| Sidelobe | Tone to Lower Uplink Band | | 119.33 | feet |
| | Tone to Upper Uplink Band | | 119.33 | feet |
| | Tone to Adjacent Channel | | 11.93 | feet |
| 1 | Class A: Modulated to Lower Uplink Band | | 1,193.28 | feet |
| | Class A: Modulated to Upper Uplink Band | | 119.33 | feet |
| | Class A: Modulated to Adjacent Channel | | 84.48 | feet |
| | Class B: Modulated to Lower Uplink Band | | 377.35 | feet |
| ŀ | Class B: Modulated to Upper Uplink Band | | 119.33 | feet |
| | Class B: Modulated to Adjacent Channel | | 37.73 | feet |
| • | Class C: Modulated to Lower Uplink Band | | 119.33 | feet |
| 1 | Class C: Modulated to Upper Uplink Band | | 119.33 | feet |
| | Class C: Modulated to Adjacent Channel | | 11.93 | feet |

Downlink on Downlink Separation Distance RSU to OBU

| Downlink on Downlink Separation Distance 1000 to OBS | | | | | |
|--|---------------------------------------|-------|--------|-------|--|
| RSU Antenna | Antennas SCENARIO | LABEL | VALUE | UNITS | |
| Mainlobe | Same Channel | | 752.91 | feet | |
| | Tone - Adjacent Channel | | 0.08 | feet | |
| | Class A: Modulated - Adjacent Channel | | 0.53 | feet | |
| | Class B: Modulated - Adjacent Channel | | 0.24 | feet | |
| | Class C: Modulated - Adjacent Channel | | 0.08 | feet | |
| Sidelobe | Same Channel | | 133.89 | feet | |
| | Tone - Adjacent Channel | | 0.01 | feet | |
| | Class A: Modulated - Adjacent Channel | | 0.09 | feet | |
| 1 | Class B: Modulated - Adjacent Channel | | 0.04 | feet | |
| | Class C: Modulated - Adjacent Channel | | 0.01 | feet | |

| RSU Antenna | Antennas | SCENARIO | LABEL | VALUE | UNITS |
|-------------|-----------------|----------|-------|-------|-------|
| N/A | Same Channel | · | | 0.84 | feet |
| | Adjacent Channe | | | 0.11 | feet |

APPENDIX B-1 In-Vehicle Signing Versus Exit Beacon Calculations of Minimum Separation Distances Assuming 50' Range In-Vehicle Signing Beacons

CALCULATIONS OF RE-USE DISTANCES: IN-VEHICLE SIGNING (1) TO EXIT BEACON (2)

Beacon Operating Parameters

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|-------------|--|-----------|-----------|-------------|
| General | Center Frequency | Fc | 5.85 | GHz |
| | Speed of Light | Cf | 984251969 | feet/sec. |
| | Wavelength | Lambda | 0.1682482 | feet |
| | Wavelength in dB | Lambda_dB | -7.74 | dB feet |
| | 4*PI | F_PI | 10.99 | dB |
| Beacon 1 | Height of RSU Antenna | RSU_h | 20.00 | feet |
| (In-Vehicle | Height of OBU Antenna | OBU_h | 5.00 | feet |
| Signing | Maximum Lateral Separation Distance | Sep_max | 50.00 | feet |
| Beacon) | Minumum RSU Ant. Angle From Vertical | Ang_min | 45.00 | degrees |
| | Minimum Lateral Separation Distance | Sep_min | 15.00 | feet |
| | Maximum Operating Range | Rmax | 52.20 | feet |
| | Maximum Operating Range in dB | Rmax_dB | 17.18 | dB feet |
| | Minimum Operating Range | Rmin | 21.21 | feet |
| | Minimum Operating Range in dB | Rmin_dB | 13.27 | dB feet |
| i | Width of Antenna Beam at Longest Range | Wmax | 12.00 | |
| | Antenna Elevation Beamwidth | RSU_el | 28.30 | |
| | Antenna Azimuth Beamwidth | RSU_az | 13.11 | degrees |
| | Antenna Gain | RSU_g | 19.76 | |
| | Maximum Antenna Gain Through Sidelobes | RSU_gsl | 4.76 | |
| Beacon 2 | Height of RSU Antenna | RSU2_h | 20.00 | |
| (Exit | Height of OBU Antenna | OBU2_h | 5.00 | |
| Beacon) | Maximum Lateral Separation Distance | Sep2_max | 15.00 | |
| | Minumum RSU Ant. Angle From Vertical | Ang2_min | -45.00 | |
| | Minimum Lateral Separation Distance | Sep2_min | -15.00 | |
| <u> </u> | Maximum Operating Range | Rmax2 | 21.21 | |
| | Maximum Operating Range in dB | Rmax2_dB | | |
| | Minimum Operating Range | Rmin2 | 12.00 | |
| | Minimum Operating Range in dB | Rmin2_dB | | |
| | Width of Antenna Beam at Longest Range | Wmax2 | 5.00 | |
| 1 | Antenna Elevation Beamwidth | RSU2_el | 90.00 | |
| ļ | Antenna Azimuth Beamwidth | RSU2_az | 13.44 | |
| | Antenna Gain | RSU2_g | 14.62 | |
| | Maximum Antenna Gain Through Sidelobes | RSU2_gsl | | |
| RSU General | | RSU_gl | 3.00 | |
| | Minimum Loss Through Antenna Sidelobes | RSU_sl | 15.00 | |
| | Minimum Received Signal Level (at receiver) | RSU_mrsl | | |
| | Maximum Interference Signal Level | RSU_int | -114.00 | |
| | Isolation Tone to Lower Uplink Band | RSU_TL | 60.00 | |
| ļ | Isolation Tone to Upper Uplink Band | RSU_TU | 60.00 | |
| 1 | Isolation Tone to Adjacent Channel | RSU_TA | 80.00 | |
| | Class A: Isolation Modulated to Lower Uplink | RSU_AML | | |
| | Class A: Isolation Modulated to Upper Uplink | RSU_AML | | |
| Į. | Class A: Isolation Modulated to Adjacent Channel | RSU_AMA | | |
| | Class B: Isolation Modulated to Lower Uplink | RSU_BML | | |
| | Class B: Isolation Modulated to Upper Uplink | RSU_BML | | |
| | Class B: Isolation Modulated to Adjacent Channel | RSU_BMA | | |
| | Class C: Isolation Modulated to Lower Uplink | RSU_CML | | |
| | Class C: Isolation Modulated to Upper Uplink | RSU_CMU | | |
| | Class C: Isolation Modulated to Adjacent Channel | RSU_CMA | 80.00 |) dB |

CALCULATIONS OF RE-USE DISTANCES: IN-VEHICLE SIGNING (1) TO EXIT BEACON (2) (CONTINUED)

OBU Operating Parameters

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|---|----------|--------|-------|
| OBU | Antenna Gain (35 degrees off boresight) | OBU_g | 4.00 | dB |
| | Mimimum Received Signal Level (0 dB ant.) | OBU_min | -40.00 | dBm |
| | Maximum Received Signal Level (0 dB ant.) | OBU_max | -14.00 | dBm |
| 1 | Maximum Interference Signal Level (0 dB ant.) | OBU_int | -60.00 | dBm |
| l l | Maximum Transmit EIRP | OBU_Pmax | -24.00 | dBm |
| 1 | Windscreen Loss, One-Way | L_w | 3.00 | dB |
| | Modulation Loss | L_m | 3.00 | ďB |
| | Realization Margin | L_r | 4.00 | dB |
| Ì | RF Amplifier Gain | OBU_rf | 10.00 | dB |
| | Minimum Conversion Gain | OBU_Gain | 5.00 | dB |
| | Adjacent Channel Isolation | OBU_AI | 18.00 | dB |

Beacon 1 Required Transmit Power Calculations

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|----------|--------|-------|
| RSU | Transmit Power for Successful Downlink | Pt_d | 15.06 | dBm |
| | Transmit Power for Successful Uplink | Pt_u | 11.13 | dBm |
| | Transmit Power for Up and Down Link | Pt | 15.06 | dBm |
| £ | Transmit EIRP | RSU_EIRP | 34.82 | dBm |
| OBU | Max. Received Signal Level (0 dB ant.) | OBU_Rmax | -29.18 | dBm |

Beacon 2 Required Transmit Power Calculations

| Donation in the Control of the Contr | | | | | |
|--|--|-----------|--------|-------|--|
| LOCATION | PARAMETER | LABEL | VALUE | UNITS | |
| RSU | Transmit Power for Successful Downlink | Pt2_d | 12.37 | dBm | |
| | Transmit Power for Successful Uplink | Pt2_u | 5.75 | dBm | |
| | Transmit Power for Up and Down Link | Pt2 | 12.37 | dBm | |
| | Transmit EIRP | RSU2_EIRP | 27.00 | dBm | |
| OBU | Max. Received Signal Level (0 dB ant.) | BU2_Rma | -32.05 | dBm | |

CALCULATIONS OF RE-USE DISTANCES: IN-VEHICLE SIGNING (1) TO EXIT BEACON (2) (CONTINUED)

Uplink on Uplink Separation Distance OBU to RSU Antennas

| RSU ANT. | SCENARIO | 2 on 1 | 1 on 2 | UNITS |
|----------|------------------|--------|--------|-------|
| Sidelobe | Same Channel | 515.21 | 397.22 | feet |
| | Adjacent Channel | 64.86 | 50.01 | feet |

Downlink on Uplink Separation Distance RSU to RSU Antennas

| RSU ANT. | SCENARIO | 2 on 1 | 1 on 2 | UNITS |
|----------|---|--------|--------|-------|
| Sidelobe | Tone to Lower Uplink Band | 46.18 | 62.93 | feet |
| | Tone to Upper Uplink Band | 46.18 | 62.93 | feet |
| | Tone to Adjacent Channel | 4.62 | 6.29 | feet |
| | Class A: Modulated to Lower Uplink Band | 461.77 | 629.35 | feet |
| | Class A: Modulated to Upper Uplink Band | 46.18 | 62.93 | feet |
| | Class A: Modulated to Adjacent Channel | 32.69 | 44.55 | feet |
| | Class B: Modulated to Lower Uplink Band | 146.02 | 199.02 | feet |
| | Class B: Modulated to Upper Uplink Band | 46.18 | 62.93 | feet |
| | Class B: Modulated to Adjacent Channel | 14.60 | 19.90 | feet |
| | Class C: Modulated to Lower Uplink Band | 46.18 | 62.93 | feet |
| | Class C: Modulated to Upper Uplink Band | 46.18 | 62.93 | feet |
| | Class C: Modulated to Adjacent Channel | 4.62 | 6.29 | feet |

Downlink on Downlink Separation Distance RSU to OBU Antennas

| RSU ANT. | SCENARIO | 2 on 1 | 1 on 2 | UNITS |
|----------|---------------------------------------|--------|--------|-------|
| Sidelobe | Same Channel | 53.29 | 131.12 | feet |
| | Tone - Adjacent Channel | 0.01 | 0.01 | feet |
| | Class A: Modulated - Adjacent Channel | 0.04 | 0.09 | feet |
| | Class B: Modulated - Adjacent Channel | 0.02 | 0.04 | feet |
| | Class C: Modulated - Adjacent Channel | 0.01 | 0.01 | feet |

| RSU ANT. | SCENARIO | 2 on 1 | 1 on 2 | UNITS |
|----------|------------------|--------|--------|-------|
| N/A | Same Channel | 0.59 | 0.83 | feet |
| | Adjacent Channel | 0.07 | 0.10 | feet |

APPENDIX B-2 IN-VEHICLE SIGNING VERSUS EXIT BEACON CALCULATIONS OF MINIMUM SEPARATION DISTANCES ASSUMING 100' RANGE IN-VEHICLE SIGNING BEACONS

CALCULATIONS OF RE-USE DISTANCES: IN-VEHICLE SIGNING (1) TO EXIT BEACON (2)

Beacon Operating Parameters

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|-------------|---|-----------|----------------------|-------------|
| General | Center Frequency | Fc | 5.85 | GHz |
| Joneran | Speed of Light | Cf | 984251969 | |
| | Wavelength | Lambda | 0.1682482 | feet |
|] | Wavelength in dB | Lambda dB | -7.74 | dB feet |
| | 4*Pl | F Pi | 10.99 | dB |
| Beacon 1 | Height of RSU Antenna | RSU h | 20.00 | feet |
| (In-Vehicle | Height of OBU Antenna | OBU h | 5.00 | feet |
| Signing | Maximum Lateral Separation Distance | Sep_max | 100.00 | feet |
| Beacon) | Minumum RSU Ant. Angle From Vertical | Ang_min | 45.00 | degrees |
| Deacon) | Minimum Lateral Separation Distance | Sep_min | 15.00 | feet |
| | Maximum Operating Range | Rmax | 101.12 | feet |
| | Maximum Operating Range in dB | Rmax dB | 20.05 | dB feet |
| [| Minimum Operating Range | Rmin | 21.21 | feet |
| | Minimum Operating Range in dB | Rmin dB | 13.27 | dB feet |
| [| Width of Antenna Beam at Longest Range | Wmax | 12.00 | feet |
| | Antenna Elevation Beamwidth | RSU el | 36.47 | degrees |
| ĺ | Antenna Azimuth Beamwidth | RSU az | 6.79 | |
| ļ | Antenna Gain | RSU_g | 21.51 | degrees |
| | Maximum Antenna Gain Through Sidelobes | RSU_gsl | 6.51 | dB |
| Beacon 2 | Height of RSU Antenna | RSU2_h | 20.00 | feet |
| • | Height of OBU Antenna | OBU2 h | 5.00 | |
| (Exit | | | | |
| Beacon) | Maximum Lateral Separation Distance | Sep2_max | | |
| | Minumum RSU Ant. Angle From Vertical | Ang2_min | -45.00 | |
| 1 | Minimum Lateral Separation Distance | Sep2_min | -15.00 | |
| | Maximum Operating Range | Rmax2 | 21.21 | |
| ľ | Maximum Operating Range in dB | Rmax2_dB | | |
| | Minimum Operating Range | Rmin2 | 12.00 | |
| Ì | Minimum Operating Range in dB | Rmin2_dB | | |
| | Width of Antenna Beam at Longest Range Antenna Elevation Beamwidth | Wmax2 | 5.00 | |
| İ | | RSU2_el | 90.00 | |
| ļ | Antenna Azimuth Beamwidth | RSU2_az | 13.44 | |
| ł | Antenna Gain | RSU2_g | 14.62 | |
| RSU General | Maximum Antenna Gain Through Sidelobes Antenna Radiation Pattern Loss | RSU2_gsl | -0.38 3.00 | · |
| RSU General | | RSU_gl | | |
| 1 | Minimum Loss Through Antenna Sidelobes | RSU_sl | 15.00 | |
| ę | Minimum Received Signal Level (at receiver) | RSU_mrsl | | |
| | Maximum Interference Signal Level | RSU_int | -114.00 | |
| | Isolation Tone to Lower Uplink Band | RSU_TL | 60.00 | |
| 1 | Isolation Tone to Upper Uplink Band | RSU_TU | 60.00 | |
| 1 | Isolation Tone to Adjacent Channel | RSU_TA | 80.00 | |
| | Class A: Isolation Modulated to Lower Uplink | RSU_AML | | |
| ì | Class A: Isolation Modulated to Upper Uplink | RSU_AML | | |
| | Class A: Isolation Modulated to Adjacent Channel | RSU_AMA | | |
| | Class B: Isolation Modulated to Lower Uplink | RSU_BML | | |
| | Class B: Isolation Modulated to Upper Uplink | RSU_BML | | |
| 1 | Class B: Isolation Modulated to Adjacent Channel | RSU_BMA | | |
| | Class C: Isolation Modulated to Lower Uplink | RSU_CML | | |
| | Class C: Isolation Modulated to Upper Uplink | RSU_CMU | | |
| | Class C: Isolation Modulated to Adjacent Channel | RSU_CMA | 80.00 |) dB |

CALCULATIONS OF RE-USE DISTANCES: IN-VEHICLE SIGNING (1) TO EXIT BEACON (2) (CONTINUED)

OBU Operating Parameters

| ore operating that the second of the second | | | | |
|---|---|----------|--------|-------|
| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
| OBU | Antenna Gain (35 degrees off boresight) | OBU_g | 4.00 | dB |
| | Mimimum Received Signal Level (0 dB ant.) | OBU_min | -40.00 | dBm |
| | Maximum Received Signal Level (0 dB ant.) | OBU_max | -14.00 | dBm |
| | Maximum Interference Signal Level (0 dB ant.) | OBU_int | -60.00 | dBm |
| | Maximum Transmit EIRP | OBU_Pmax | -24.00 | dBm |
| | Windscreen Loss, One-Way | L_w | 3.00 | dB |
| 1 | Modulation Loss | L_m | 3.00 | dB |
| • | Realization Margin | L_r | 4.00 | dΒ |
| | RF Amplifier Gain | OBU_rf | 10.00 | dB |
| | Minimum Conversion Gain | OBU_Gain | 5.00 | dB |
| | Adjacent Channel Isolation | OBU_AI | 18.00 | ₫B |

Beacon 1 Required Transmit Power Calculations

| LOCATION | DADAMETED | LABEL | VALUE | LINUTO |
|----------|--|----------|--------|--------|
| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
| RSU | Transmit Power for Successful Downlink | Pt_d | 19.05 | dBm |
| | Transmit Power for Successful Uplink | Pt_u | 19.10 | dBm |
| | Transmit Power for Up and Down Link | Pt | 19.10 | dBm |
| | Transmit EIRP | RSU_EIRP | 40.61 | dBm |
| OBU | Max. Received Signal Level (0 dB ant.) | OBU_Rmax | -23.39 | dBm |

Beacon 2 Required Transmit Power Calculations

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|-----------|--------|-------|
| RSU | Transmit Power for Successful Downlink | Pt2_d | 12.37 | dBm |
| Ì | Transmit Power for Successful Uplink | Pt2_u | 5.75 | dBm |
| | Transmit Power for Up and Down Link | Pt2 | 12.37 | dBm |
| | Transmit EIRP | RSU2_EIRP | 27.00 | dBm |
| OBU | Max. Received Signal Level (0 dB ant.) | BU2_Rma | -32.05 | dBm |

CALCULATIONS OF RE-USE DISTANCES: IN-VEHICLE SIGNING (1) TO EXIT BEACON (2) (CONTINUED)

Uplink on Uplink Separation Distance OBU to RSU Antennas

| RSU ANT. | SCENARIO | 2 on 1 | 1 on 2 | UNITS |
|----------|------------------|--------|--------|-------|
| Sidelobe | Same Channel | 630.66 | 405.46 | feet |
| | Adjacent Channel | 79.40 | 51.04 | feet |

Downlink on Uplink Separation Distance RSU to RSU Antennas

| RSU ANT. | SCENARIO | 2 on 1 | 1 on 2 | UNITS |
|----------|---|--------|----------|-------|
| Sidelobe | Tone to Lower Uplink Band | 56.52 | 122.60 | feet |
| | Tone to Upper Uplink Band | 56.52 | 122.60 | feet |
| | Tone to Adjacent Channel | 5.65 | 12.26 | feet |
| | Class A: Modulated to Lower Uplink Band | 565.24 | 1,226.03 | feet |
| | Class A: Modulated to Upper Uplink Band | 56.52 | 122.60 | feet |
| | Class A: Modulated to Adjacent Channel | 40.02 | 86.80 | feet |
| | Class B: Modulated to Lower Uplink Band | 178.75 | 387.71 | feet |
| | Class B: Modulated to Upper Uplink Band | 56.52 | 122.60 | feet |
| | Class B: Modulated to Adjacent Channel | 17.87 | 38.77 | feet |
| | Class C: Modulated to Lower Uplink Band | 56.52 | 122.60 | feet |
| | Class C: Modulated to Upper Uplink Band | 56.52 | 122.60 | feet |
| | Class C: Modulated to Adjacent Channel | 5.65 | 12.26 | feet |

Downlink on Downlink Separation Distance RSU to OBU Antennas

| RSU ANT. | SCENARIO | 2 on 1 | 1 on 2 | UNITS |
|----------|---------------------------------------|--------|--------|-------|
| Sidelobe | Same Channel | 53.29 | 255.44 | feet |
| | Tone - Adjacent Channel | 0.01 | 0.03 | feet |
| | Class A: Modulated - Adjacent Channel | 0.04 | 0.18 | feet |
| | Class B: Modulated - Adjacent Channel | 0.02 | 0.08 | feet |
| | Class C: Modulated - Adjacent Channel | 0.01 | 0.03 | feet |

| RSU ANT. | SCENARIO | 2 on 1 | 1 on 2 | UNITS |
|----------|------------------|--------|--------|-------|
| N/A | Same Channel | 0.59 | 0.84 | feet |
| [| Adjacent Channel | 0.07 | 0.11 | feet |

APPENDIX C-1 In-Vehicle Signing Beacons with 50' Operating Range Calculations of Minimum Separation Distances

CALCULATION OF RE-USE DISTANCES BETWEEN IN-VEHICLE SIGNING

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|-----------|----------|-------------|
| General | Center Frequency | Fc | 5.85 | GHz |
| 1 - | Height of RSU Antenna | RSU_h | 20.00 | feet |
| | Height of OBU Antenna | OBU h | 5.00 | feet |
| | Maximum Lateral Separation Distance | Sep_max | 50.00 | feet |
| | Minimum RSU Ant. Angle From Vertical | Ang_min | 45.00 | degrees |
| | Minimum Lateral Separation Distance | Sep_min | 15.00 | feet |
| | Maximum Operating Range | Rmax | 52.20 | feet |
| | Maximum Operating Range in dB | Rmax_dB | 17.18 | dB feet |
| | Minimum Operating Range | Rmin | 21.21 | feet |
| l i | Minimum Operating Range in dB | Rmin_dB | 13.27 | dB feet |
| | Width of Antenna Beam at Longest Range | Wmax | 12.00 | feet |
| | Speed of Light | Cf | 9.84E+08 | |
| | Wavelength | Lambda | 0.168248 | feet |
| | Wavelength in dB | Lambda_dB | | |
| | 4*P1 | FPI | 10.99 | dB |
| RSU | Antenna Elevation Beamwidth | RSU el | 28.30 | degrees |
| | Antenna Azimuth Beamwidth | RSU az | 13.11 | degrees |
| | Antenna Gain | RSU_g | 19.76 | dB |
| | Antenna Radiation Pattern Loss | RSU_gl | 3.00 | dB |
| | Minimum Loss Through Antenna Sidelobes | RSU sl | 15.00 | dB |
| | Maximum Antenna Gain Through Sidelobes | RSU_gsl | 4.76 | dB |
| 1 | Minimum Received Signal Level (at rcvr) | RSU_mrsl | -94.00 | dBm |
| Į | Maximum Interference Signal | RSU int | -114.00 | dBm |
| | Isolation Tone to Lower Uplink Band | RSU TL | 60.00 | dB |
| Ì | Isolation Tone to Upper Uplink Band | RSU TU | 60.00 | dB |
| i i | Isolation Tone to Adjacent Channel | RSU TA | 80.00 | dB |
| | Class A: Isolation Modulated to Lower Uplink | RSU AML | 40.00 | dB |
| <u> </u> | Class A: Isolation Modulated to Upper Uplink | RSU AMU | 60.00 | dB |
| | Class A: Isolation Modulated to Adjacent Channel | RSU AMA | 63.00 | dB |
| <u>l</u> | Class B: Isolation Modulated to Lower Uplink | RSU BML | 50.00 | dB |
| 1 | Class B: Isolation Modulated to Upper Uplink | RSU BMU | 60.00 | dB |
| | Class B: Isolation Modulated to Adjacent Channel | RSU BMA | 70.00 | |
| | Class C: Isolation Modulated to Lower Uplink | RSU CML | 60.00 | |
| Į | Class C: Isolation Modulated to Upper Uplink | RSU CMU | 60.00 | |
| [| Class C: Isolation Modulated to Adjacent Channel | RSU_CMA | 80.00 | |
| OBU | Antenna Gain (35 degrees off boresight) | OBU_g | 4.00 | |
| | Mimimum Received Signal Level (0 dB ant) | OBU_min | -40.00 | dBm |
| | Maximum Received Signal Level (0 dB ant) | OBU_max | -14.00 | dBm |
| | Maximum Interference Signal Level (0 dB ant) | OBU_int | -60.00 | dBm |
| | Maximum Transmit EIRP | OBU_Pmax | | |
| | Windscreen Loss, One-Way | L_w | 3.00 | dB |
| | Modulation Loss | L_m | 3.00 | |
| | Realization Margin | L_r | 4.00 | |
| 1 | RF Amplifier Gain | OBU_rf | 10.00 | |
| | Minimum Conversion Gain | OBU Gain | | |
|] | Adjacent Channel Isolation | OBU_AI | 18.00 | |

CALCULATION OF RE-USE DISTANCES BETWEEN IN-VEHICLE SIGNING BEACONS (CONTINUED)

RSU Required Transmit Power Calculations

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|----------|--------|-------|
| RSU | Transmit Power for Successful Downlink | Pt_d | 15.06 | dBm |
| | Transmit Power for Successful Uplink | Pt_u | 11.13 | dBm |
| | Transmit Power for Up and Down Link | Pt | 15.06 | dBm |
| | Transmit EIRP | RSU_EIRP | 34.82 | dBm |
| OBU | Max. Received Signal Level (0 dB ant.) | OBU_Rmax | -29.18 | dBm |

Uplink on Uplink Separation Distance OBU to RSU Antennas

| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
|----------|------------------|-------|--------|-------|
| Sidelobe | Same Channel | | 717.19 | feet |
| | Adjacent Channel | | 90.29 | feet |

Downlink on Uplink Separation Distance RSU to RSU Antennas

| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
|----------|---|-------|----------|-------|
| Sidelobe | Tone to Lower Uplink Band | | 113.63 | feet |
| | Tone to Upper Uplink Band | | 113.63 | feet |
| | Tone to Adjacent Channel | | 11.36 | feet |
| | Class A: Modulated to Lower Uplink Band | | 1,136.31 | feet |
| | Class A: Modulated to Upper Uplink Band | | 113.63 | feet |
| | Class A: Modulated to Adjacent Channel | | 80.44 | feet |
| | Class B: Modulated to Lower Uplink Band | | 359.33 | feet |
| | Class B: Modulated to Upper Uplink Band | | 113.63 | feet |
| | Class B: Modulated to Adjacent Channel | | 35.93 | feet |
| | Class C: Modulated to Lower Uplink Band | | 113.63 | feet |
| | Class C: Modulated to Upper Uplink Band | | 113.63 | feet |
| | Class C: Modulated to Adjacent Channel | | 11.36 | feet |

Downlink on Downlink Separation Distance RSU to OBU Antennas

| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS | |
|----------|---------------------------------------|-------|--------|-------|--|
| Sidelobe | Same Channel | | 131.12 | feet | |
| | Tone - Adjacent Channel | | 0.01 | feet | |
| | Class A: Modulated - Adjacent Channel | | 0.09 | feet | |
| | Class B: Modulated - Adjacent Channel | | 0.04 | feet | |
| | Class C: Modulated - Adjacent Channel | | 0.01 | feet | |

| | opinii on sommin ospanancii sistani | | | |
|----------|-------------------------------------|-------|-------|-------|
| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
| N/A | Same Channel | | 0.83 | feet |
| | Adjacent Channel | | 0.10 | feet |

APPENDIX C-2 In-Vehicle Signing Beacons with 100' Operating Range Calculations of Minimum Separation Distances

CALCULATION OF RE-USE DISTANCE BETWEEN IN-VEHICLE SIGNING BEACONS

| Center Frequency | General Operating Parameters LABEL VALUE UNITS | | | | |
|--|---|--|---------|-------------|---------|
| Height of RSU Antenna | | PARAMETER | LABEL | | UNITS |
| Height of OBU Antenna | | | | | GHz |
| Maximum Lateral Separation Distance Sep_max 100.00 | | <u> </u> | | | feet |
| Minimum RSU Ant. Angle From Vertical Ang_min 45.00 di | | | | | feet |
| Minimum Lateral Separation Distance Sep_min 15.00 | | | | | feet |
| Maximum Operating Range Rmax 101.12 Maximum Operating Range in dB Rmax_dB 20.05 Minimum Operating Range Rmin 21.21 Minimum Operating Range in dB Rmin_dB 13.27 Width of Antenna Beam at Longest Range Wmax 12.00 Speed of Light Cf 9.84E+08 fe Wavelength Lambda 0.168248 Wavelength in dB Lambda 0.168248 Wavelength in dB Lambda dB -7.74 4*PI F_PI 10.99 RSU Antenna Elevation Beamwidth RSU_gL 36.47 d Antenna Azimuth Beamwidth RSU_gL 36.47 d Antenna Radiation Pattern Loss RSU_gL 3.00 Minimum Coss Through Antenna Sidelobes RSU_gL 3.00 Minimum Received Signal Level (at receiver) RSU_gl 3.50 Maximum Interference Signal Level RSU_mrsl -94.00 Maximum Interference Signal Level RSU_mrsl -94.00 Isolation Tone to Lower Uplink Band RSU_TL 60.00 <td>_</td> <td></td> <td></td> <td></td> <td>degrees</td> | _ | | | | degrees |
| Maximum Operating Range in dB | | | | | feet |
| Minimum Operating Range in dB | | | | | feet |
| Minimum Operating Range in dB Width of Antenna Beam at Longest Range Speed of Light Wavelength Wavelength Wavelength in dB Lambda dB 4*Pl RSU Antenna Elevation Beamwidth Antenna Azimuth Beamwidth RSU_el 36.47 d Antenna Azimuth Beamwidth RSU_g 21.51 Antenna Radiation Pattern Loss RSU_gl 3.00 Minimum Loss Through Antenna Sidelobes Maximum Antenna Gain Through Sidelobes RSU_sl 15.00 Maximum Antenna Gain Through Sidelobes RSU_gl 6.51 Minimum Received Signal Level (at receiver) RSU_mrsl -94.00 Isolation Tone to Lower Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TL 60.00 Class A: Isolation Modulated to Lower Uplink Class A: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Lower Uplink Class B: Isolation Modulated to Upper Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated to Object Uplink Class C: Isolation Modulated Upper Uplink Class C: Isolation Modulated Upper Uplink Class C: Isolation Modulated Upper Uplink Class C: Isolation Modulated Upper Uplink Class C: Isolati | | | | | dB feet |
| Width of Antenna Beam at Longest Range Speed of Light Cf 9.84E+08 fe Wavelength Lambda 0.168248 Wavelength in dB Lambda Lambda Manual Lambda Manual Lambda Manual Lambda Manual | | | | | feet |
| Speed of Light Lambda 0.168248 Wavelength Lambda 0.168248 Wavelength in dB Lambda dB -7.74 cd 4*Pl F_Pl 10.99 | | | | | dB feet |
| Wavelength Lambda Lambda Mayelength in dB Lambda Mayelength in dB Lambda Lambda Mayelength in dB Lambda Mayelength in dB Lambda Mayelength in dB F PI 10.99 | | | | | feet |
| Wavelength in dB 4*Pl F_Pl 10.99 RSU Antenna Elevation Beamwidth RSU_el 36.47 d Antenna Azimuth Beamwidth RSU_gl 21.51 Antenna Radiation Pattern Loss RSU_gl 3.00 Minimum Loss Through Antenna Sidelobes RSU_gl 3.00 Maximum Antenna Gain Through Sidelobes RSU_gsl 6.51 Minimum Received Signal Level (at receiver) Maximum Interference Signal Level Isolation Tone to Lower Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TL 60.00 Isolation Tone to Adjacent Channel Class A: Isolation Modulated to Lower Uplink Class A: Isolation Modulated to Upper Uplink Class A: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Adjacent Channel RSU_AMA 63.00 Class B: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Lower Uplink Class B: Isolation Modulated to Lower Uplink Class B: Isolation Modulated to Lower Uplink Class C: Isolation Modulated to Lower Uplink Class C: Isolation Modulated to Resu_BML Class C: Isolation Modulated to Resu_BML Class C: Isolation Modulated to Lower Uplink RSU_BML 60.00 Class C: Isolation Modulated to Lower Uplink RSU_BML 60.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Maximum Received Signal Level (0 dB ant.) Maximum Received Signal Level (0 dB ant.) Maximum Interference Signal Level (0 dB ant.) Maximum Interference Signal Level (0 dB ant.) Maximum Interference Signal Level (0 dB ant.) Maximum Transmit EIRP | | | | | |
| A*PI | | | | | feet |
| Antenna Elevation Beamwidth RSU_el 36.47 d Antenna Azimuth Beamwidth RSU_az 6.79 d Antenna Gain RSU_g 21.51 Antenna Radiation Pattern Loss RSU_gl 3.00 Minimum Loss Through Antenna Sidelobes RSU_gl 3.00 Maximum Antenna Gain Through Sidelobes RSU_gl 6.51 Minimum Received Signal Level (at receiver) RSU_mrsl -94.00 Maximum Interference Signal Level RSU_int -114.00 Isolation Tone to Lower Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TL 60.00 Isolation Tone to Adjacent Channel RSU_TA 80.00 Class A: Isolation Modulated to Lower Uplink RSU_AML 40.00 Class A: Isolation Modulated to Upper Uplink RSU_AML 60.00 Class B: Isolation Modulated to Adjacent Channel RSU_AMA 63.00 Class B: Isolation Modulated to Lower Uplink RSU_BML 50.00 Class B: Isolation Modulated to Lower Uplink RSU_BML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Opper Uplink RSU_CML 60.00 Maximum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Interference Signal Level (0 dB ant.) OBU_min -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | V | Wavelength in dB | | | dB feet |
| Antenna Azimuth Beamwidth Antenna Gain Antenna Gain Antenna Radiation Pattern Loss RSU_gl 3.00 Minimum Loss Through Antenna Sidelobes RSU_gl 3.00 Maximum Antenna Gain Through Sidelobes RSU_gsl 6.51 Minimum Received Signal Level (at receiver) RSU_mrsl -94.00 Maximum Interference Signal Level RSU_int -114.00 Isolation Tone to Lower Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TL 60.00 Isolation Tone to Adjacent Channel RSU_TA 80.00 Class A: Isolation Modulated to Lower Uplink RSU_AML 40.00 Class A: Isolation Modulated to Upper Uplink Class A: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Lower Uplink Class C: Isolation Modulated to Lower Uplink Class C: Isolation Modulated to Upper Uplink Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Lower Uplink RSU_BMA 70.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Maximum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Interference Signal Level (0 dB ant.) OBU_pmax -14.00 Maximum Transmit EIRP OBU_Pmax -24.00 | | | | | dB |
| Antenna Gain Antenna Radiation Pattern Loss RSU_gl 3.00 Minimum Loss Through Antenna Sidelobes RSU_sl 15.00 Maximum Antenna Gain Through Sidelobes RSU_gsl 6.51 Minimum Received Signal Level (at receiver) RSU_mrsl -94.00 Maximum Interference Signal Level (at receiver) RSU_mrsl -94.00 Maximum Interference Signal Level RSU_int -114.00 Isolation Tone to Lower Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TL 60.00 Isolation Tone to Adjacent Channel RSU_TA 80.00 Class A: Isolation Modulated to Lower Uplink RSU_AML 40.00 Class A: Isolation Modulated to Upper Uplink RSU_AML 60.00 Class A: Isolation Modulated to Adjacent Channel RSU_AMA 63.00 Class B: Isolation Modulated to Lower Uplink RSU_BML 50.00 Class B: Isolation Modulated to Upper Uplink RSU_BML 60.00 Class B: Isolation Modulated to Adjacent Channel RSU_BML 60.00 Class C: Isolation Modulated to Lower Uplink RSU_BMA 70.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Maximum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Interference Signal Level (0 dB ant.) OBU_max -14.00 Maximum Transmit EIRP OBU_Pmax -24.00 | | | | | degrees |
| Antenna Radiation Pattern Loss RSU_gl 3.00 Minimum Loss Through Antenna Sidelobes RSU_sl 15.00 Maximum Antenna Gain Through Sidelobes RSU_gsl 6.51 Minimum Received Signal Level (at receiver) RSU_mrsl -94.00 Maximum Interference Signal Level RSU_int -114.00 Isolation Tone to Lower Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TU 60.00 Isolation Tone to Adjacent Channel RSU_TA 80.00 Class A: Isolation Modulated to Lower Uplink RSU_AML 40.00 Class A: Isolation Modulated to Upper Uplink RSU_AMU 60.00 Class A: Isolation Modulated to Adjacent Channel RSU_AMA 63.00 Class B: Isolation Modulated to Lower Uplink RSU_BML 50.00 Class B: Isolation Modulated to Upper Uplink RSU_BML 60.00 Class B: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Upper Uplink RSU_BMU 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Maximum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Interference Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_int -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | <u> </u> | | | | degrees |
| Minimum Loss Through Antenna Sidelobes RSU_sl 15.00 Maximum Antenna Gain Through Sidelobes RSU_gsl 6.51 Minimum Received Signal Level (at receiver) RSU_mrsl -94.00 Maximum Interference Signal Level RSU_int -114.00 Isolation Tone to Lower Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TU 60.00 Isolation Tone to Adjacent Channel RSU_TA 80.00 Class A: Isolation Modulated to Lower Uplink RSU_AML 40.00 Class A: Isolation Modulated to Upper Uplink RSU_AML 60.00 Class B: Isolation Modulated to Lower Uplink RSU_BML 63.00 Class B: Isolation Modulated to Upper Uplink RSU_BML 50.00 Class B: Isolation Modulated to Upper Uplink RSU_BML 60.00 Class B: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_BMA 70.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Maximum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_min -60.00 | <u> </u> | | | | dB |
| Maximum Antenna Gain Through Sidelobes RSU_gsl 6.51 Minimum Received Signal Level (at receiver) RSU_mrsl -94.00 Maximum Interference Signal Level RSU_int -114.00 Isolation Tone to Lower Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TU 60.00 Isolation Tone to Adjacent Channel RSU_TA 80.00 Class A: Isolation Modulated to Lower Uplink RSU_AML 40.00 Class A: Isolation Modulated to Upper Uplink RSU_AML 60.00 Class A: Isolation Modulated to Adjacent Channel RSU_AMA 63.00 Class B: Isolation Modulated to Lower Uplink RSU_BML 50.00 Class B: Isolation Modulated to Upper Uplink RSU_BML 60.00 Class B: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Maximum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_max -24.00 | | | | | dB |
| Minimum Received Signal Level (at receiver) Maximum Interference Signal Level Isolation Tone to Lower Uplink Band Isolation Tone to Upper Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TA 80.00 Class A: Isolation Modulated to Lower Uplink Class A: Isolation Modulated to Upper Uplink RSU_AML Class A: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Adjacent Channel Class B: Isolation Modulated to Lower Uplink RSU_BML 60.00 Class B: Isolation Modulated to Upper Uplink RSU_BML 60.00 Class B: Isolation Modulated to Upper Uplink RSU_BML 60.00 Class B: Isolation Modulated to Upper Uplink RSU_BML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CMU 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 OBU Antenna Gain (35 degrees off boresight) OBU_g Anon Maximum Received Signal Level (0 dB ant.) Maximum Received Signal Level (0 dB ant.) Maximum Interference Signal Level (0 dB ant.) OBU_min -40.00 Maximum Transmit EIRP OBU_Pmax -24.00 | | | RSU_si | | dB |
| Maximum Interference Signal Level RSU_int -114.00 Isolation Tone to Lower Uplink Band RSU_TL 60.00 Isolation Tone to Upper Uplink Band RSU_TU 60.00 Isolation Tone to Adjacent Channel RSU_TA 80.00 Class A: Isolation Modulated to Lower Uplink RSU_AML 40.00 Class A: Isolation Modulated to Upper Uplink RSU_AMU 60.00 Class A: Isolation Modulated to Adjacent Channel RSU_AMA 63.00 Class B: Isolation Modulated to Lower Uplink RSU_BML 50.00 Class B: Isolation Modulated to Upper Uplink RSU_BMU 60.00 Class B: Isolation Modulated to Upper Uplink RSU_BMA 70.00 Class C: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 OBU Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Interference Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_pmax -24.00 | | | | | dB |
| Isolation Tone to Lower Uplink Band | | | | | |
| Isolation Tone to Upper Uplink Band Isolation Tone to Adjacent Channel RSU_TA RSU_AML Class A: Isolation Modulated to Lower Uplink RSU_AML Class A: Isolation Modulated to Upper Uplink RSU_AMA Class A: Isolation Modulated to Adjacent Channel RSU_AMA Class B: Isolation Modulated to Lower Uplink RSU_BML Class B: Isolation Modulated to Lower Uplink RSU_BML Class B: Isolation Modulated to Upper Uplink RSU_BMU Class B: Isolation Modulated to Adjacent Channel RSU_BMA Class C: Isolation Modulated to Lower Uplink RSU_CML Class C: Isolation Modulated to Lower Uplink RSU_CML Class C: Isolation Modulated to Upper Uplink RSU_CML Class C: Isolation Modulated to Upper Uplink RSU_CMU Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CML 60.00 Class C: Isolation Modulated to Adjacent Chann | P | Maximum Interference Signal Level | | -114.00 | dBm |
| Isolation Tone to Adjacent Channel Class A: Isolation Modulated to Lower Uplink Class A: Isolation Modulated to Upper Uplink Class A: Isolation Modulated to Upper Uplink Class A: Isolation Modulated to Adjacent Channel Class B: Isolation Modulated to Lower Uplink Class B: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Upper Uplink Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Lower Uplink Class C: Isolation Modulated to Upper Uplink Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Opper Uplink Class C: Isolation Modulated Tolation Class C: Isolation Modulated Tolation Class C: Isolation Modulated Tolation Class C: Isolation Modulated | 1 | Isolation Tone to Lower Uplink Band | | 60.00 | ₫B |
| Class A: Isolation Modulated to Lower Uplink Class A: Isolation Modulated to Upper Uplink Class A: Isolation Modulated to Upper Uplink Class A: Isolation Modulated to Adjacent Channel Class B: Isolation Modulated to Lower Uplink Class B: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Upper Uplink Class B: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Lower Uplink Class C: Isolation Modulated to Upper Uplink Class C: Isolation Modulated to Upper Uplink Class C: Isolation Modulated to Upper Uplink Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Adjacent Channel Class C: Isolation Modulated to Upper Uplink Class C: Isolation | [1 | Isolation Tone to Upper Uplink Band | | 60.00 | ₫B |
| Class A: Isolation Modulated to Upper Uplink RSU_AMA 63.00 Class A: Isolation Modulated to Adjacent Channel RSU_AMA 63.00 Class B: Isolation Modulated to Lower Uplink RSU_BML 50.00 Class B: Isolation Modulated to Upper Uplink RSU_BMU 60.00 Class B: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CMU 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 OBU Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_int -60.00 Maximum Interference Signal Level (0 dB ant.) OBU_pmax -14.00 Maximum Transmit EIRP OBU_Pmax -24.00 | [1 | Isolation Tone to Adjacent Channel | RSU_TA | 80.00 | dB |
| Class A: Isolation Modulated to Adjacent Channel RSU_AMA 63.00 Class B: Isolation Modulated to Lower Uplink RSU_BML 50.00 Class B: Isolation Modulated to Upper Uplink RSU_BMU 60.00 Class B: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CMU 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMU 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 OBU Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_int -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | | Class A: Isolation Modulated to Lower Uplink | RSU_AML | 40.00 | dB |
| Class B: Isolation Modulated to Lower Uplink RSU_BML 60.00 Class B: Isolation Modulated to Upper Uplink RSU_BMU 60.00 Class B: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CMU 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 OBU Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_int -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | | Class A: Isolation Modulated to Upper Uplink | RSU_AMU | 60.00 | dB |
| Class B: Isolation Modulated to Upper Uplink RSU_BMU 60.00 Class B: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CMU 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_int -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | [| Class A: Isolation Modulated to Adjacent Channel | RSU_AMA | 63.00 | dB |
| Class B: Isolation Modulated to Adjacent Channel RSU_BMA 70.00 Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CMU 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 OBU Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_int -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | | Class B: Isolation Modulated to Lower Uplink | RSU_BML | 50.00 | ₫₿ |
| Class C: Isolation Modulated to Lower Uplink RSU_CML 60.00 Class C: Isolation Modulated to Upper Uplink RSU_CMU 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 OBU Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_int -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | | Class B: Isolation Modulated to Upper Uplink | RSU_BMU | 60.00 | dB |
| Class C: Isolation Modulated to Upper Uplink RSU_CMU 60.00 Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 OBU Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_int -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | Į. | Class B: Isolation Modulated to Adjacent Channel | RSU_BMA | 70.00 | dB |
| Class C: Isolation Modulated to Adjacent Channel RSU_CMA 80.00 Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_int -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | | Class C: Isolation Modulated to Lower Uplink | RSU_CML | 60,00 | dB |
| OBU Antenna Gain (35 degrees off boresight) OBU_g 4.00 Mimimum Received Signal Level (0 dB ant.) OBU_min -40.00 Maximum Received Signal Level (0 dB ant.) OBU_max -14.00 Maximum Interference Signal Level (0 dB ant.) OBU_int -60.00 Maximum Transmit EIRP OBU_Pmax -24.00 | [1 | Class C: Isolation Modulated to Upper Uplink | RSU_CMU | 60.00 | dB |
| Mimimum Received Signal Level (0 dB ant.) Maximum Received Signal Level (0 dB ant.) Maximum Interference Signal Level (0 dB ant.) Maximum Transmit EIRP OBU_max -14.00 OBU_int -60.00 OBU_Pmax -24.00 | Ī | Class C: Isolation Modulated to Adjacent Channel | RSU_CMA | 80.00 | dB |
| Maximum Received Signal Level (0 dB ant.) Maximum Interference Signal Level (0 dB ant.) Maximum Transmit EIRP OBU_max -14.00 OBU_int -60.00 OBU_Pmax -24.00 | OBU . | Antenna Gain (35 degrees off boresight) | OBU_g | 4.00 | dB |
| Maximum Received Signal Level (0 dB ant.) Maximum Interference Signal Level (0 dB ant.) Maximum Transmit EIRP OBU_max -14.00 OBU_int -60.00 OBU_Pmax -24.00 | Ţ | Mimimum Received Signal Level (0 dB ant.) | OBU_min | -40.00 | dBm |
| Maximum Interference Signal Level (0 dB ant.) Maximum Transmit EIRP OBU_int -60.00 OBU_Pmax -24.00 | | | OBU_max | -14.00 | dBm |
| Maximum Transmit EIRP OBU_Pmax -24.00 | | | | | |
| | | | | | |
| IVVindscreen Loss, One-Way I L w I 3.00 | | Windscreen Loss, One-Way | L_w | 3.00 | |
| Modulation Loss L_m 3.00 | | | | | |
| Realization Margin L r 4.00 | L | | | | |
| RF Amplifier Gain OBU_rf 10.00 | | | | | |
| Minimum Conversion Gain OBU Gain 5.00 | | | | | |
| Adjacent Channel Isolation OBU_AI 18.00 | | | | | |

CALCULATION OF RE-USE DISTANCE BETWEEN IN-VEHICLE SIGNING BEACONS (CONTINUED)

RSU Required Transmit Power Calculations

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|----------|--------|-------|
| RSU | Transmit Power for Successful Downlink | Pt_d | 19.05 | dBm |
| 1 | Transmit Power for Successful Uplink | Pt_u | 19.10 | dBm |
| | Transmit Power for Up and Down Link | Pt | 19.10 | dBm |
| i | Transmit EIRP | RSU_EIRP | 40.61 | dBm |
| OBU | Max. Received Signal Level (0 dB ant.) | OBU_Rmax | -23.39 | dBm |

Uplink on Uplink Separation Distance OBU to RSU Antennas

| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
|----------|------------------|-------|--------|-------|
| Sidelobe | Same Channel | | 896.13 | feet |
| | Adjacent Channel | | 112.82 | feet |

Downlink on Uplink Separation Distance RSU to RSU Antennas

| RSU ANT. | SCENARIO SCENARIO | LABEL | VALUE | UNITS |
|----------|---|-------|----------|-------|
| Sidelobe | Tone to Lower Uplink Band | 0.000 | 270.97 | feet |
| Sidelobe | Tone to Upper Uplink Band | | 270.97 | feet |
| | | | 27.10 | |
| | Tone to Adjacent Channel | | | feet |
| | Class A: Modulated to Lower Uplink Band | | 2,709.71 | feet |
| | Class A: Modulated to Upper Uplink Band | | 270.97 | feet |
| | Class A: Modulated to Adjacent Channel | | 191.83 | feet |
| | Class B: Modulated to Lower Uplink Band | | 856.89 | feet |
| | Class B: Modulated to Upper Uplink Band | | 270.97 | feet |
| | Class B: Modulated to Adjacent Channel | | 85.69 | feet |
| | Class C: Modulated to Lower Uplink Band | | 270.97 | feet |
| | Class C: Modulated to Upper Uplink Band | | 270.97 | feet |
| | Class C: Modulated to Adjacent Channel | | 27.10 | feet |

Downlink on Downlink Separation Distance RSU to OBU Antennas

| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
|----------|---------------------------------------|-------|--------|-------|
| Sidelobe | Same Channel | | 255.44 | feet |
| | Tone - Adjacent Channel | | 0.03 | feet |
| | Class A: Modulated - Adjacent Channel | | 0.18 | feet |
| | Class B: Modulated - Adjacent Channel | | 0.08 | feet |
| | Class C: Modulated - Adjacent Channel | | 0.03 | feet |

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|----------|---------------------------------------|-------|-------|-------|
| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
| N/A | Same Channel | | 0.84 | feet |
| | Adjacent Channel | | 0.11 | feet |

APPENDIX D-1 INTERSECTION BEACONS WITH 50' OPERATING RANGE CALCULATIONS OF MINIMUM SEPARATION DISTANCES

CALCULATION OF RE-USE DISTANCE BETWEEN INTERSECTION BEACONS

| LOCATION | PARAMETER Parameters | LABEL | VALUE | UNITS |
|----------|--|------------|----------------|---------------------------------------|
| | | Fc | 5.85 | GHz |
| General | Center Frequency | RSU_h | 20.00 | |
| | Height of RSU Antenna | OBU h | 5.00 | feet |
| | Height of OBU Antenna | | | feet |
| | Maximum Lateral Separation Distance | Sep_max | 50.00 30.00 | feet |
| | Minumum RSU Ant. Angle From Vertical | Ang_min | | degrees |
| | Minimum Lateral Separation Distance | Sep_min | 8.66 | feet |
| | Maximum Operating Range | Rmax | 52.20 | feet |
| | Maximum Operating Range in dB | Rmax_dB | 17.18 | dB feet |
| | Minimum Operating Range | Rmin | 17.32 | feet |
| | Minimum Operating Range in dB | Rmin_dB | 12.39 | dB feet |
| | Width of Antenna Beam at Longest Range | Wmax | 12.00 | feet |
| | Speed of Light | Cf | 9.84E+08 | · · · · · · · · · · · · · · · · · · · |
| | Wavelength | Lambda | 0.168248 | feet |
| | Wavelength in dB | Lambda_dB | | dB feet |
| | 4*PI | F_PI | 10.99 | dB |
| RSU | Antenna Elevation Beamwidth (Hor. to Ang_min) | RSU_el | 60.00 | degrees |
| | Antenna Azimuth Beamwidth | RSU_az | 13.11 | degrees |
| | Antenna Gain | RSU_g | 16.49 | dB |
| | Antenna Radiation Pattern Loss | RSU_gl | 3.00 | dB |
| | Minimum Loss Through Antenna Sidelobes | RSU_sl | 15.00 | dB |
| | Maximum Antenna Gain Through Sidelobes | RSU_gsl | 1.49 | dB |
| | Minimum Received Signal Level (at receiver) | RSU_mrsl | -94.00 | dBm |
| | Maximum Interference Signal Level | RSU_int | -114.00 | dBm |
| | Isolation Tone to Lower Uplink Band | RSU_TL | 60.00 | dB |
| 1 | Isolation Tone to Upper Uplink Band | RSU_TU | 60.00 | ₫B |
| ł | Isolation Tone to Adjacent Channel | RSU_TA | 80.00 | ₫B |
| | Class A: Isolation Modulated to Lower Uplink | RSU_AML | 40.00 | ₫B |
| | Class A: Isolation Modulated to Upper Uplink | RSU_AMU | 60.00 | ₫B |
| 1 | Class A: Isolation Modulated to Adjacent Channel | RSU_AMA | 63.00 | dB |
| | Class B: Isolation Modulated to Lower Uplink | RSU_BML | 50.00 | dB |
| ļ | Class B: Isolation Modulated to Upper Uplink | RSU_BMU | 60.00 | dB |
| | Class B: Isolation Modulated to Adjacent Channel | RSU_BMA | 70.00 | dB |
| | Class C: Isolation Modulated to Lower Uplink | RSU_CML | 60.00 | dB |
| | Class C: Isolation Modulated to Upper Uplink | RSU_CMU | 60.00 | dB |
| | Class C: Isolation Modulated to Adjacent Channel | RSU_CMA | | |
| OBU | Antenna Gain (35 degrees off boresight) | OBU_g | 4.00 | dB |
| | Mimimum Received Signal Level (0 dB ant.) | OBU_min | -40.00 | dBm |
| | Maximum Received Signal Level (0 dB ant.) | OBU_max | | |
| | Maximum Interference Signal Level (0 dB ant.) | OBU_int | -60.00 | |
| | Maximum Transmit EIRP | OBU Pmax | | |
| | Windscreen Loss, One-Way | L_w | 3.00 | |
| | Modulation Loss | L_m | 3.00 | |
| | Realization Margin | <u>L_r</u> | 4.00 | |
| 1 | RF Amplifier Gain | OBU_rf | 10.00 | |
| | Minimum Conversion Gain | OBU_Gain | | |
| | Adjacent Channel Isolation | OBU_AI | 18.00 | |
| | Andarent Chamier Isolation | OBU_AI | 10.00 | up up |

CALCULATION OF RE-USE DISTANCE BETWEEN INTERSECTION BEACONS (CONTINUED)

RSU Required Transmit Power Calculations

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|----------|--------|-------|
| RSU | Transmit Power for Successful Downlink | Pt_d | 18.33 | dBm |
| 1 | Transmit Power for Successful Uplink | Pt_u | 17.65 | dBm |
| | Transmit Power for Up and Down Link | Pt | 18.33 | dBm |
| ł | Transmit EIRP | RSU_EIRP | 34.82 | dBm |
| OBU | Max. Received Signal Level (0 dB ant.) | OBU_Rmax | -27.42 | dBm |

Uplink on Uplink Separation Distance OBU to RSU Antennas

| | SCENARIO | Sidelobe | Mainlobe | UNITS |
|-----------------|----------|----------|----------|-------|
| Same Channel | | 502.78 | 2,827.35 | feet |
| Adjacent Channe | el | 63.30 | 355.94 | feet |

Downlink on Uplink Separation Distance RSU to RSU Antennas

| Downlink on opinik Separation Distance NSO to NSO Antennas | | | | |
|--|--|----------|-----------|-------|
| | SCENARIO | Sidelobe | Mainlobe | UNITS |
| To | one to Lower Uplink Band | 78.04 | 2,467.87 | feet |
| To | one to Upper Uplink Band | 78.04 | 2,467.87 | feet |
| To | one to Adjacent Channel | 7.80 | 246.79 | feet |
| CI | ass A: Modulated to Lower Uplink Band | 780.41 | 24,678.69 | feet |
| CI | ass A: Modulated to Upper Uplink Band | 78.04 | 2,467.87 | feet |
| CI | ass A: Modulated to Adjacent Channel | 55.25 | 1,747.12 | feet |
| Ci | ass B: Modulated to Lower Uplink Band | 246.79 | 7,804.09 | feet |
| CI | lass B: Modulated to Upper Uplink Band | 78.04 | 2,467.87 | feet |
| CI | ass B: Modulated to Adjacent Channel | 24.68 | 780.41 | feet |
| CI | lass C: Modulated to Lower Uplink Band | 78.04 | 2,467.87 | feet |
| C | lass C: Modulated to Upper Uplink Band | 78.04 | 2,467.87 | feet |
| С | lass C: Modulated to Adjacent Channel | 7.80 | 246.79 | feet |

Downlink on Downlink Separation Distance RSU to OBU Antennas

| SCENARIO | Sidelobe | Mainlobe | UNITS |
|---------------------------------------|----------|----------|-------|
| Same Channel | 131.12 | 737.37 | feet |
| Tone - Adjacent Channel | 0.01 | 0.07 | feet |
| Class A: Modulated - Adjacent Channel | 0.09 | 0.52 | feet |
| Class B: Modulated - Adjacent Channel | 0.04 | 0.23 | feet |
| Class C: Modulated - Adjacent Channel | 0.01 | 0.07 | feet |

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|----------|-------------------------------------|--------------------------|-------|
| RSU ANT. | SCENARIO | VALUE | UNITS |
| N/A | Same Channel | 0.84 | feet |
| | Adjacent Channel | 0.11 | feet |

APPENDIX D-2 INTERSECTION BEACONS WITH 100' OPERATING RANGE CALCULATIONS OF MINIMUM SEPARATION DISTANCES

CALCULATION OF RE-USE DISTANCE BETWEEN INTERSECTION BEACONS

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|--------------|---------------|--------------|
| General | Center Frequency | Fc | 5.85 | GHz |
| General | Height of RSU Antenna | RSU_h | 20.00 | feet |
| | Height of OBU Antenna | OBU_h | 5.00 | feet |
| | Maximum Lateral Separation Distance | Sep_max | 100.00 | feet |
| | Minumum RSU Ant. Angle From Vertical | Ang_min | 30.00 | degrees |
| ŀ | Minimum Lateral Separation Distance | Sep_min | 8.66 | feet |
| | Maximum Operating Range | Rmax | 101.12 | feet |
| | Maximum Operating Range in dB | Rmax_dB | 20.05 | dB feet |
| | Minimum Operating Range | Rmin | 17.32 | feet |
| ľ | Minimum Operating Range in dB | Rmin_dB | 12.39 | dB feet |
| | Width of Antenna Beam at Longest Range | Wmax | 12.00 | feet |
| | Speed of Light | Cf | 9.84E+08 | |
| | Wavelength | Lambda | 0.168248 | feet |
| | Wavelength in dB | Lambda dB | | |
| | 4*PI | F PI | 10.99 | dB |
| RSU | Antenna Elevation Beamwidth (Hor. to Ang_min) | RSU_el | 60.00 | |
| , KSO | Antenna Azimuth Beamwidth | RSU az | 6.79 | |
| | Antenna Gain | RSU_g | 19.35 | dB |
| | Antenna Radiation Pattern Loss | RSU_gl | 3.00 | dB |
| | Minimum Loss Through Antenna Sidelobes | RSU_sl | 15.00 | dB |
| | Maximum Antenna Gain Through Sidelobes | RSU_gsl | 4.35 | dB |
| · · | Minimum Received Signal Level (at receiver) | RSU_mrsl | -94.00 | dBm |
| | Maximum Interference Signal Level | RSU int | -114.00 | dBm |
| | Isolation Tone to Lower Uplink Band | RSU TL | 60.00 | dB |
| | Isolation Tone to Upper Uplink Band | RSU TU | 60.00 | dB |
| | Isolation Tone to Opper Opinik Band | RSU TA | 80.00 | dB |
| 1 | Class A: Isolation Modulated to Lower Uplink | RSU_AML | 40.00 | dB |
| | Class A: Isolation Modulated to Lower Opinik Class A: Isolation Modulated to Upper Uplink | RSU_AMU | 60.00 | dB |
| | Class A: Isolation Modulated to Opper Opinik Class A: Isolation Modulated to Adjacent Channel | RSU_AMA | 63.00 | dB |
| | Class B: Isolation Modulated to Adjacent Channel Class B: Isolation Modulated to Lower Uplink | RSU_BML | 50.00 | |
| İ | Class B: Isolation Modulated to Lower Opinik | RSU BMU | 60.00 | |
| | Class B: Isolation Modulated to Opper Opinix Class B: Isolation Modulated to Adjacent Channel | RSU_BMA | 70.00 | |
| 1 | Class C: Isolation Modulated to Lower Uplink | RSU CML | 60.00 | |
| | Class C: Isolation Modulated to Lower Opinik | RSU_CMU | 60.00 | 1 |
| | Class C: Isolation Modulated to Adjacent Channel | RSU_CMA | | |
| OBU | Antenna Gain (35 degrees off boresight) | OBU_g | 4.00 | |
| 1 000 | Mimimum Received Signal Level (0 dB ant.) | OBU_min | -40.00 | |
| | Maximum Received Signal Level (0 dB ant.) | OBU_max | | • |
| | Maximum Interference Signal Level (0 dB ant.) | OBU_int | -60.00 | |
| 1 | Maximum Transmit EIRP | OBU_Pmax | | |
| 1 | Windscreen Loss, One-Way | L_w | 3.00 | |
| | Modulation Loss | - | 3.00 | |
| | | L_m | 4.00 | |
| | Realization Margin RF Amplifier Gain | L_r | | + |
| | | OBU_rf | 10.00 5.00 | |
| | Minimum Conversion Gain | OBU_Gain | | |
| | Adjacent Channel Isolation | OBU_AI | 18.00 |) dB |

CALCULATION OF RE-USE DISTANCE BETWEEN INTERSECTION BEACONS (CONTINUED)

RSU Required Transmit Power Calculations

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|----------|--------|-------|
| RSU | Transmit Power for Successful Downlink | Pt_d | 21.21 | dBm |
| • | Transmit Power for Successful Uplink | Pt_u | 23.42 | dBm |
| | Transmit Power for Up and Down Link | Pt | 23.42 | dBm |
| İ | Transmit EIRP | RSU_EIRP | 42.77 | dBm |
| OBU | Max. Received Signal Level (0 dB | OBU_Rmax | -19.46 | dBm |
| | ant.) | | | |

Uplink on Uplink Separation Distance OBU to RSU Antennas

| | SCENARIO | Sidelobe | Mainlobe | UNITS |
|------|--------------|----------|----------|-------|
| San | ne Channel | 698.65 | 3,928.78 | feet |
| Adja | cent Channel | 87.95 | 494.60 | feet |

Downlink on Uplink Separation Distance RSU to RSU Antennas

| Downlink on opinik Separation Distance RSO to RSO Antennas | | | | |
|--|----------|-----------|-------|--|
| SCENARIO | Sidelobe | Mainlobe | UNITS | |
| Tone to Lower Uplink Band | 270.97 | 8,568.85 | feet | |
| Tone to Upper Uplink Band | 270.97 | 8,568.85 | feet | |
| Tone to Adjacent Channel | 27.10 | 856.89 | feet | |
| Class A: Modulated to Lower Uplink Band | 2,709.71 | 85,688.54 | feet | |
| Class A: Modulated to Upper Uplink Band | 270.97 | 8,568.85 | feet | |
| Class A: Modulated to Adjacent Channel | 191.83 | 6,066.28 | feet | |
| Class B: Modulated to Lower Uplink Band | 856.89 | 27,097.10 | feet | |
| Class B: Modulated to Upper Uplink Band | 270.97 | 8,568.85 | feet | |
| Class B: Modulated to Adjacent Channel | 85.69 | 2,709.71 | feet | |
| Class C: Modulated to Lower Uplink Band | 270.97 | 8,568.85 | feet | |
| Class C: Modulated to Upper Uplink Band | 270.97 | 8,568.85 | feet | |
| Class C: Modulated to Adjacent Channel | 27.10 | 856.89 | feet | |

Downlink on Downlink Separation Distance RSU to OBU Antennas

| | SCENARIO | Sidelobe | Mainlobe | UNITS |
|----|---------------------------------------|----------|----------|-------|
| | Same Channel | 327.65 | 1,842.49 | feet |
| 1 | Tone - Adjacent Channel | 0.03 | 0.18 | feet |
| Į. | Class A: Modulated - Adjacent Channel | 0.23 | 1.30 | feet |
| | Class B: Modulated - Adjacent Channel | 0.10 | 0.58 | feet |
| | Class C: Modulated - Adjacent Channel | 0.03 | 0.18 | feet |

| RSU ANT. | SCENARIO | VALUE | UNITS |
|----------|------------------|-------|-------|
| N/A | Same Channel | 0.84 | feet |
| | Adjacent Channel | 0.11 | feet |

APPENDIX E BUS STOP BEACONS CALCULATIONS OF MINIMUM SEPARATION DISTANCES

CALCULATION OF RE-USE DISTANCE BETWEEN BUS STOP BEACONS

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|-----------------|----------------|---------------|
| General | Center Frequency | Fc | 5.85 | GHz |
| Conora | Height of RSU Antenna | RSU h | 20.00 | feet |
| | Height of OBU Antenna | OBU_h | 12.00 | feet |
| | Maximum Lateral Separation Distance | Sep_max | 4.00 | feet |
| | Minimum Lateral Separation Distance | Sep_min | 8.00 | feet |
| | Maximum Operating Range | Rmax | 8.94 | feet |
| | Maximum Operating Range in dB | Rmax_dB | 9.52 | dB feet |
| 1 | Minimum Operating Range | Rmin | 5.00 | feet |
| į | Minimum Operating Range in dB | Rmin_dB | 6.99 | dB feet |
| Ï | Width of Antenna Beam at Longest Range | Wmax | 5.00 | feet |
| | Speed of Light | Cf | 9.84E+08 | |
| | Wavelength | Lambda | 0.168248 | feet |
| | Wavelength in dB | Lambda_dB | -7.74 | dB feet |
| 500 | 4*PI | F_PI | 10.99 | dB |
| RSU | Antenna Elevation Beamwidth | RSU_el | 31.23 | degrees |
| | Antenna Azimuth Beamwidth | RSU_az RSU_g | 31.23 15.56 | degrees dB |
| } | Antenna Gain Antenna Radiation Pattern Loss | RSU_gl | 3.00 | dB |
| [| Minimum Loss Through Antenna Sidelobes | RSU_sl | 15.00 | dB |
| | Maximum Antenna Gain Through Sidelobes | RSU_gsl | 0.56 | dB |
| 1 | Minimum Received Signal Level (at receiver) | RSU_mrsl | -94.00 | dBm |
| | Maximum Interference Signal Level | RSU_int | -114.00 | dBm |
| l. | Isolation Tone to Lower Uplink Band | RSU TL | 60.00 | dB |
| | Isolation Tone to Upper Uplink Band | RSU TU | 60.00 | dB |
| İ | Isolation Tone to Adjacent Channel | RSU TA | 80.00 | dB |
| | Class A: Isolation Modulated to Lower Uplink | RSU AML | 40.00 | dB |
| | Class A: Isolation Modulated to Upper Uplink | RSU_AMU | 60.00 | dB |
| 1 | Class A: Isolation Modulated to Adjacent Channel | RSU_AMA | 63.00 | ₫B |
| | Class B: Isolation Modulated to Lower Uplink | RSU_BML | 50.00 | dB |
| | Class B: Isolation Modulated to Upper Uplink | RSU_BMU | 60.00 | dB |
| | Class B: Isolation Modulated to Adjacent Channel | RSU_BMA | 70.00 | dB |
| | Class C: Isolation Modulated to Lower Uplink | RSU_CML | 60.00 | dB |
| | Class C: Isolation Modulated to Upper Uplink | RSU_CMU | | dB |
| | Class C: Isolation Modulated to Adjacent Channel | RSU_CMA | | |
| OBU | Antenna Gain (35 degrees off boresight) | OBU_g | 4.00 | |
| | Minimum Loss Through Antenna Sidelobes | OBU_sl | 15.00 | |
| ļ | Mimimum Received Signal Level (0 dB ant.) | OBU_min | -40.00 | |
| | Maximum Received Signal Level (0 dB ant.) | OBU_max | | |
| 1 | Maximum Interference Signal Level (0 dB ant.) | OBU_int | -60.00 | |
| } | Maximum Transmit EIRP | OBU_Pmax | | |
| 1 | Windscreen Loss, One-Way | L_W | 3.00 | |
| l | Modulation Loss | L_m | 3.00 | |
| | Realization Margin | L_r | 4.00 | |
| | RF Amplifier Gain | OBU_rf | 10.00 | |
| | Minimum Conversion Gain | OBU_Gain | | |
| L | Adjacent Channel Isolation | OBU_AI | 18.00 | dB_ |

CALCULATION OF RE-USE DISTANCE BETWEEN BUS STOP BEACONS (CONTINUED)

RSU Required Transmit Power Calculations

| LOCATION | PARAMETER | LABEL | VALUE | UNITS |
|----------|--|----------|--------|-------|
| RSU | Transmit Power for Successful Downlink | Pt_d | 3.94 | dBm |
| | Transmit Power for Successful Uplink | Pt_u | -11.13 | dBm |
| ł | Transmit Power for Up and Down Link | Pt | 3.94 | dBm |
| | Transmit EIRP | RSU_EIRP | 19.50 | dBm |
| OBU | Max. Received Signal Level (0 dB ant.) | OBU_Rmax | -31.95 | dBm |

Uplink on Uplink Separation Distance OBU to RSU Antennas

| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
|----------|------------------|-------|-------|-------|
| Sidelobe | Same Channel | | 57.19 | feet |
| | Adjacent Channel | | 7.20 | feet |

Downlink on Uplink Separation Distance RSU to RSU Antennas

| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
|----------|---|-------|--------|-------|
| Sidelobe | Tone to Lower Uplink Band | | 12.01 | feet |
| | Tone to Upper Uplink Band | | 12.01 | feet |
| i | Tone to Adjacent Channel | | 1.20 | feet |
| | Class A: Modulated to Lower Uplink Band | | 120.09 | feet |
| | Class A: Modulated to Upper Uplink Band | | 12.01 | feet |
| | Class A: Modulated to Adjacent Channel | | 8.50 | feet |
| | Class B: Modulated to Lower Uplink Band | | 37.98 | feet |
| | Class B: Modulated to Upper Uplink Band | | 12.01 | feet |
| } | Class B: Modulated to Adjacent Channel | | 3.80 | feet |
| | Class C: Modulated to Lower Uplink Band | | 12.01 | feet |
| | Class C: Modulated to Upper Uplink Band | | 12.01 | feet |
| | Class C: Modulated to Adjacent Channel | | 1.20 | feet |

Downlink on Downlink Separation Distance RSU to OBU Antennas

| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
|----------|---------------------------------------|-------|-------|-------|
| Sidelobe | Same Channel | | 4.00 | feet |
| | Tone - Adjacent Channel | | 0.00 | feet |
| | Class A: Modulated - Adjacent Channel | | 0.00 | feet |
| | Class B: Modulated - Adjacent Channel | | 0.00 | feet |
| | Class C: Modulated - Adjacent Channel | | 0.00 | feet |

| RSU ANT. | SCENARIO | LABEL | VALUE | UNITS |
|----------|------------------|-------|-------|-------|
| N/A | Same Channel | | 0.11 | feet |
| | Adjacent Channel | | 0.01 | feet |